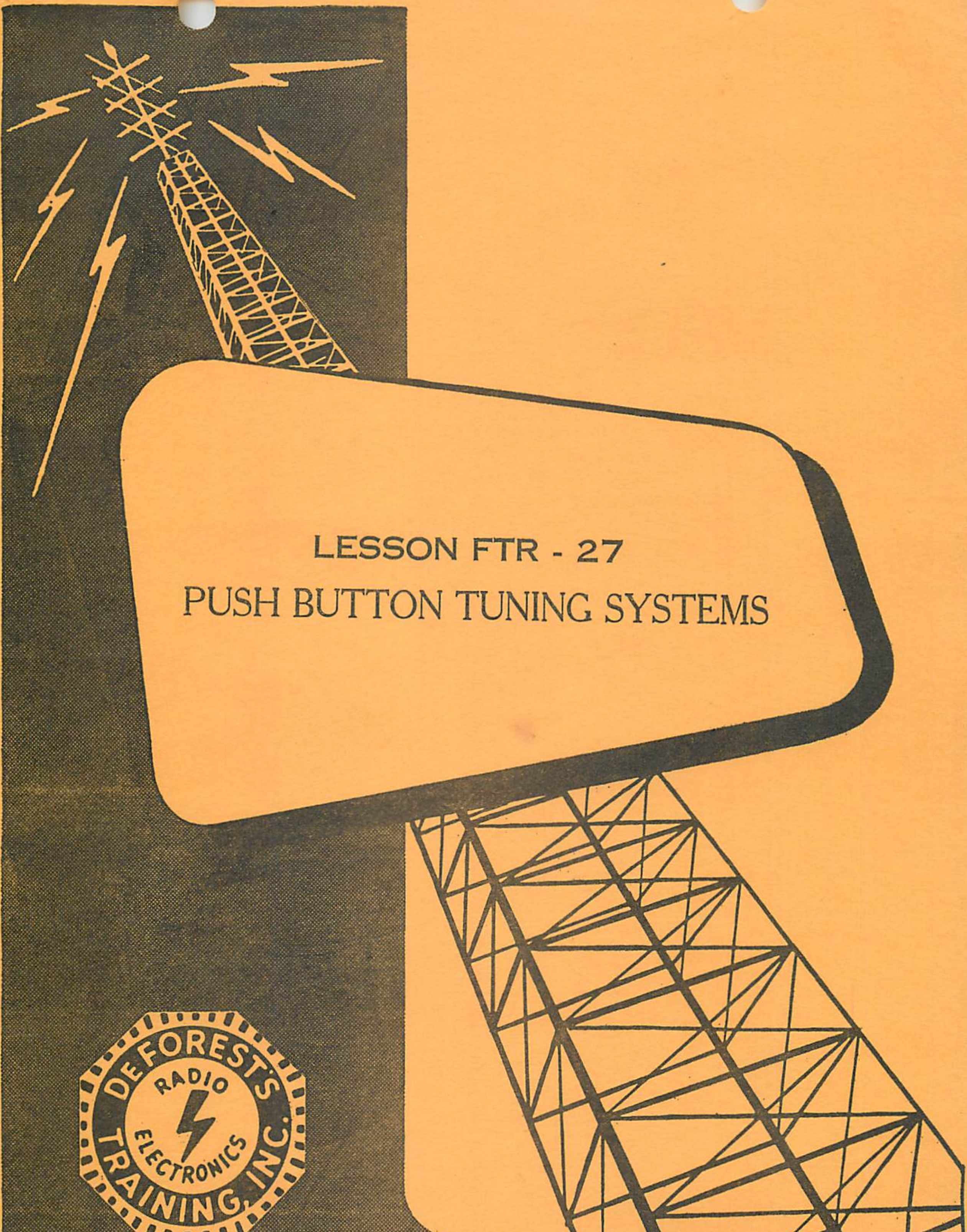


LESSON FTR - 27

PUSH BUTTON TUNING SYSTEMS

DE FOREST'S TRAINING, INC.

2533 N. Ashland Ave., Chicago 14, Illinois

LESSON FTR-27

PUSH-BUTTON TUNING SYSTEMS

Mechanically Operated Manual Type ---------- Page 1
Motor Operated Types ---------------------- Page 1
Tuned Circuit Substitution Types ---------- Page 4
Automatic Frequency Control --------------- Page 6
Tuning Indicator -------------------------- Page 7
Meter Type Tuning Indicator --------------- Page 8
Saturable Core Tuning Indicators ---------- Page 10
Cathode Ray Tuning Indicator -------------- Page 14

# # # # #

You want a better position than you now have in business, a better and fuller place in life. All right; think of that better place and you in it as already existing. Form the mental image. Keep the image constantly before you, and -- no, you will not suddenly be transported into the higher job, but you will find that you are preparing yourself to occupy the better position in life -- your body, your energy, your understanding, your heart will grow up to the job -- and when you are ready, after hard work, after considerable preparation, you will get the job and the higher place in life.

-- Joseph H. Appel

In the past few years, automatic or push-button tuning has been adopted by practically every manufacturer of radio receivers. However, automatic station selection is not new but rather a refinement and perfection of principles which have been in use for several years.

Although the subject seems very broad, there are only three main types of automatic station selector systems which may be classified as,

1. Mechanically Operated Manual Types
2. Motor Operated Types
3. Tuned Circuit Substitution Types

The object of this Lesson is to give you an explanation of these basic systems so that you will not have any difficulty understanding the principles of operation in any automatic tuning system.

MECHANICALLY OPERATED MANUAL TYPES

As the heading indicates, this type of system is mechanically operated and functions without any electrical action. Due to this fact anyone, without technical training, can understand the operation simply by inspecting a system.

In general, however, the tuning condenser is rotated to the desired station reception position by direct mechanical effort of the person operating the receiver. This is accomplished by an arrangement of push buttons mechanically connected to a system of gears, cams and levers which are in turn connected to the rotor of the condenser gang.

The stations are pre-selected and the system is set up to them and locked. When this has been done, it is only necessary to push a button, or level, which mechanically rotates the tuning condenser to the corresponding station.

MOTOR OPERATED TYPES

With this type of system, the rotation of the variable condenser gang, to a position corresponding to a desired station tuning point, is accomplished by means of an electric motor. This system usually includes an electric motor, a station selector switch or selector buttons, a selecting commutator or other device for stopping the motor and an audio silencing circuit which operates when the motor is running.

To show you the actual operation, in Figure 1, we have the simplified circuits of such a system in which you will find the commutator mechanically connected to the condenser gang.

The selector switches, are connected in the electrical circuits of the motor winding, L, L1 and L2, the commutator and supply transformer. The motors employed in these systems are split phase induction type and therefore, no direct electrical connections are made to the armature. However, although not shown in Figure 1, the armature is mechanically coupled to the condenser shaft.

Tracing the motor circuit, we start at the secondary of the supply transformer, go through switch #5 and the motor windings up to the commutator. From here, the circuit is completed through the selector switches to ground and through it to the grounded end of the secondary.

Looking at the switches, you will notice that numbers 1, 2, 3 and 4 are normally open, closing their circuits when pushed or depressed. Switch #5, which is used to change from manual to automatic tuning, has the opposite action and is normally closed but opens its circuit when depressed.

Mechanically, the arrangement operates so that when any one switch button is depressed, all of the others are released. Thus, in normal operation, only one switch button will be depressed at any time. However, should two or more buttons be depressed at the same time, they will remain in that position until released by the operation of another button.

In order that you can understand the action, we will assume that you have the receiver in operation and desire to set up the push buttons to your favorite stations which we call A, B, C and D. As button #3 is shown depressed in Figure 1 your first step would be to depress push button #5, which would release #3, and then manually tune in station A, which we will assume moves the insulated strip of the commutator to a position between contacts 1 and 2. With station A carefully tuned in, you depress push button #1, while holding in #5, thus opening switch #5 and closing switch #1.

Under these conditions let us follow the action in the electrical circuits. From the supply secondary, the circuit is through the indicator lamp, connected across switch #5, coils L and L1, to the commutator, to contact #1 and through switch #1 to ground. Therefore, there is a complete current path which will cause the indicator lamp to light. The current, of course, will also be in the motor but, because of the lamp in series, will be too small to cause the armature to rotate.

Now, with the insulated section of the commutator between contacts 1 and 2, contact #1 is moved until it rests on the insulated section, breaks the circuit, and causes the indicator lamp to go out. Remember also, that this is the position of the selected station A. With this setup, suppose we release push buttons 1 and 5 and return the commutator to the position shown in Figure 1.

Then, as switch #5 is closed, the indicator lamp is shorted out of the circuit and by depressing push button #1 only, there will be current in the motor coils L and L_1, the commutator, contact #1 and to ground through switch #1. This current will cause the armature of the motor to revolve in a counter-clockwise direction and because of its mechanical connection to the condenser shaft, will cause both the condenser and commutator to revolve in the same direction. This motion will continue until the insulated segment of the commutator is under contact #1, breaking the circuit, and stopping the motor. As the position of contact #1 conforms to the tuning condenser's manual setting for station A, the motor has automatically tuned in this station.

Starting with the commutator insulation in a horizontal position, instead of vertical as shown, the motor current will be from the supply through coils L and L_2, thus making the armature revolve in a clockwise direction until the circuit is broken by the insulated segment, again tuning in station A.

Buttons #2, 3 and 4 are set up in exactly the same way as button #1 and will correspond to stations B, C and D. Once these buttons are set up, it is only necessary to depress one of them and the station corresponding to it will be automatically tuned in. In Figure 1, button #5 is used only to change from manual to automatic tuning and to assist in the original setting up of the selectors or push buttons.

In the beginning of this explanation, we told you that usually an audio silencing system is applied to this type of automatic tuning. This action is generally accomplished by positioning the armature of the motor slightly out of the center of the magnetic field set up by the motor coils. It is held in this off center position by a flat phosphor bronze spring which is electrically connected to ground. A contact connected to the grid of the first audio tube, is placed close to the spring. When the motor windings are energized, the armature is drawn into the center of the magnetic field, pushes the spring over and closes the circuit between it and the audio contact. This grounds the grid of the first audio stage and thus silences the system. When the motor windings are not energized, the spring holds the rotor out of position and opens the contact circuit thus allowing the audio amplifier to operate normally.

There are many variations of motor driven tuning systems but, basically they are all the same. Therefore, if you fully understand Figure 1, you will not have any difficulty with others. The number of push buttons will depend on the design and you will find systems using more or less than the number shown in Figure 1.

TUNED CIRCUIT SUBSTITUTION TYPES

In this type of automatic tuning, a latching or ladder type push button switch selects pre-calibrated tuned circuits which are substituted for the usual variable condenser tuned input and oscillator circuits. In general, there are two types of pre-set circuits in use; 1. Trimmer condenser tuning and 2. Iron core or "Permeability" tuning.

In Figure 2, we have an arrangement using trimmer condenser tuning and, in order to simplify our explanation, have shown only those circuits which are directly affected. That is, the condenser tuned input, LC, and the oscillator C1-L1. In all of these circuits, a switching arrangement is necessary to change from manual to automatic tuning and in Figure 2, this is accomplished by switch #1. The upper pair of contacts control the tuned input circuit and the lower pair control the oscillator circuit. Each pair of contacts, of course, are insulated from the other.

Notice, when button #1 is depressed, the upper pair of contacts are shorted, thus closing the circuit between C and L, which also connects to the input grid of T1. This tube is a pentagrid converter, serving as the 1st detector and oscillator of a superheterodyne receiver. Button #1 also closes the lower contacts, connects C1 to L1 which, in turn, connects to the oscillator grid of T1. Under these conditions, the circuits are conventional and the receiver tunes manually.

Suppose now we depress button #2 which as explained for Figure 1, releases #1. This will disconnect condenser C from coil L and substitute trimmer condenser C2 in its place. Likewise, in the oscillator section, condenser C1 will be replaced by trimmer condenser C3. However, the coils L and L1 remain in their proper circuits.

Thus, if C2 and C3 are adjusted and set to properly tune some desired station, it can be received by simply depressing button #2. The other buttons, 3, 4, and 5, operate exactly the same as #2 and it is only necessary to tune their trimmer condensers to the desired stations. Once this is done, the stations can be received by simply depressing a button. For manual tuning, button #1 is pushed in.

In Figure 3, we have a little different system of substitution push button tuning and, before going into the action, want you to understand the operation of switch #5. This switch is made up of two parts, one contact of which is connected to condenser C_3. As shown by the broken line, this switch arm also controls a sliding contact which changes the operation of the receiver from manual to automatic tuning.

Notice, that when this switch is closed, both ends of condenser C_3 are at ground potential, thus making the push button assembly inoperative. Closing this switch also moves the sliding contact so that the upper three circuits on each side are connected together while the lower contacts are open.

If you will trace through these circuits, you will find this movement of the contact simply makes connections so that the manual tuning circuits, L_2-C_2 and L_6-C_8, are operative. The resistance condenser combination of C_4 and R_1 is employed so that the input grid circuit can be controlled by avc.

The automatic tuning system of Figure 3 makes use of the fact that the inductance of a winding varies directly with a change in the permeability of its core material. To make use of this action, specially prepared iron slugs, which have very low loss at radio frequencies, are placed inside of the coils and so arranged that they can be mechanically moved in or out.

From your earlier lessons, you know that the permeability of these iron slugs will be much higher than that of air and as they are moved in and out of a coil, its inductance will vary accordingly. Due to the fact that the inductance can be varied, it is possible to tune over a definite band of frequencies using a fixed condenser, the same as we can tune with a fixed inductance and variable condenser.

In Figure 3, we show four sets of these coils and have indicated their functions by marking them "Ant. Coils" and "Osc. Coils". It is quite easy to gang these coils and iron slugs so that each pair may be tuned by only one adjusting knob, such as shown by the arrows extending through the coils in Figure 3. Turning this knob, will move the slugs in or out of the coils as desired.

Checking over the push button circuit, you will see that the arrangement is very similar to that of Figure 2 except here we employ tuned inductances instead of tuned trimmer condensers. Like the trimmer condensers, the inductances are preset, or tuned, to the desired station, which can then be heard simply by depressing a button.

In Figure 3, the antenna is coupled to the input grid of the first detector by condenser C_1 and condenser C_3 is employed to compensate for variations in antenna capacity. In the oscillator circuit, it is necessary to alter the tuning curve so as to provide for tracking between the oscillator and first detector circuits.

As we explained in the earlier Lessons, for the normal tuned circuit, this may be accomplished by means of a trimmer and padding condenser working in conjunction with the oscillator section of the variable condenser. However, as no variable condenser is used with the iron core coils, a different method must be employed.

It has been found that a small winding, connected in series with the oscillator grid end of the automatic windings, and so placed as not to be affected by the iron core will, if properly designed, alter the shape of the tuning curve at the high frequency portion of the coil's range. Also, when two inductances are connected in parallel, the maximum inductance is limited by the size of the smaller of the two.

In Figure 3, coil L3 is the padder winding and also serves as a means of coupling to the oscillator plate coil L4. When used in conjunction with the smaller winding mentioned above, which is L5 in Figure 3, the shape of the tuning curve is altered so as to allow excellent tracking. Variations of temperature and humidity are compensated by means of C6 which is a small fixed condenser composed of silver surfaces sprayed on a special ceramic tube. With this construction, changes of capacity due to temperature and humidity are opposite to similar changes in the coil.

The main advantage of the substitution type of automatic tuning, compared to the motor driven type is that a station is tuned in as soon as the button is depressed. In the motor driven type, one must wait until the commutator and condenser gang have rotated to the desired setting. Both, however, have an advantage over the mechanical systems which are sometimes difficult to tune exactly to resonance.

AUTOMATIC FREQUENCY CONTROL

In order to compensate for improper tuning adjustments, oscillator drift and tracking inaccuracies, some of the earlier models of the larger superheterodyne Radio Receivers employed what is known as "Automatic Frequency Control", commonly referred to as "A.F.C."

The function of this arrangement was to automatically vary the frequency of the receiver oscillator, over a predetermined range, so that the frequency difference between it and the signal frequencies was always equal to the intermediate frequency for which the receiver had been designed or tuned.

The application of A.F.C. was required to make some of the earlier Push Button Tuning systems commercially practical but, at the present time, tuning arrangements have been perfected to such an extent that A.F.C. is not needed. However, it does have some advantages but the additional tubes and circuits it requires are too expensive for the common types of Broadcast Radio Receivers.

Although A.F.C. is no longer popular, some of its circuits have been adapted for use in modern Frequency Modulation Receivers and, as these will be fully explained in the later Lessons, at this time we want to give you only a general idea of the action.

The complete A.F.C. system was required to perform two separate functions, usually by means of a "Discriminator" and a "Frequency Control" each of which required a tube.

The discriminator was used to convert changes of intermediate frequency into corresponding variations of voltage. When the incoming I.F. was too high, the discriminator produced a voltage in one direction but, when the incoming I.F. was too low, the discriminator produced a voltage in the opposite direction. When the I.F. was correct, no voltage was produced.

The amplitude or strength of these voltages was proportional to the difference between the incoming and correct intermediate frequencies and thus frequency changes were converted into corresponding changes of voltage.

The discriminator voltages were fed to the "Frequency Control" tube which operated to control the frequency of the Receiver Oscillator. With voltage in one direction, the control tube caused an increase of oscillator frequency but, with voltage in the other direction, the frequency of the oscillator was decreased.

You need not worry about the actual circuits at this time because, as mentioned above, a complete explanation of the discriminator will be found in the later Lessons.

TUNING INDICATOR

Since the advent of A.V.C., Radio Receivers have been equipped with various types of tuning indicators practically all of which operate because of the A.V.C. action.

A number of factors are responsible for the widespread adoption of tuning indicators of one type or another. Because, in addition to their usefulness in tuning to exact resonance, manufacturers realize that their incorporation constitutes an important item in increasing the attractiveness and salability of their receivers.

You have no doubt seen various shapes and sizes of receiver tuning indicators and, for the most part, probably each seemed separate and distinct. However, in general, we can put all types in three classes, and list them as,

1. Meter type indicators
2. Saturable core type indicators
3. Cathode ray indicators

For the remainder of this Lesson, we will explain each type and show you how they are connected in the circuit.

METER TYPE TUNING INDICATOR

From the explanations of the earlier Lessons, you will remember that A.V.C. operates by feeding a control voltage to one or more R.F., Mixer, and I.F. tubes. The magnitude of this control voltage depends upon the amount of signal which reaches the second detector and, applied to the grid of the controlled tubes as a negative bias, it will have an effect on their plate current. That is, when a strong signal reaches the A.V.C. rectifier, there will be a high negative bias on the control grid and the plate current will be reduced. When a low signal reaches the second detector or A.V.C. rectifier, the controlled tubes will have a minimum negative bias and maximum plate current.

From your former study of tuned circuits, you know that, at resonance, the amplitude of the impressed A.C. voltage will be maximum. Applying this to the functioning of a receiver, as a station is tuned in, the voltage at the second detector will gradually increase and be maximum at resonance. This will cause a maximum control voltage, the magnitude of which will depend on the strength of the signal, to be applied as a negative bias to the controlled tubes, reducing their plate current.

Therefore, if a sensitive current meter is placed in the plate circuits of the controlled tubes, it will register minimum current when a station is properly tuned in. The exact swing of the meter pointer will depend on the negative bias voltage applied to the controlled tubes which, in turn, depends on the strength of the input signal.

In Figure 4, we show a simplified arrangement of such a system and you will notice the meter is connected in series with the plate circuit of the controlled tube T1. Tube T2 acts as a second detector and A.V.C. rectifier, the A.V.C. control voltage being developed across R2 and C4 while resistor R1 and condenser C5 form a one section A.V.C. filter. The control grid of T1 is connected to the lower end of R1, through the I.F. transformer secondary L1, and the circuit is completed to ground through R1 and R2.

With no signal on the control grid of T1, there will be minimum bias voltage and maximum plate current which will be registered by the meter. When a signal is tuned in, there will be a voltage drop across R2, which will increase the negative bias on the control grid of T1 and thus reduce the plate current. Therefore, to tune to resonance with an incoming carrier, the tuning controls are adjusted until the meter registers the lowest plate current for that station.

In practice, you will find the meter camouflaged in many different ways, the most common, perhaps, being the shadowgraph or shadow meter. In construction, the shadow-graph indicator mechanism employs a small permanent magnet which is in the form of a circular flat ring having a small air gap.

The moving armature, which forms the indicating part of the system, consists of a flat disc of soft iron, with a rectangular slit in the center, and is mounted within this ring, so that it pivots on two opposite supports.

A thin, black opaque vane, is mounted in the middle of this slit and rigidly attached to the iron armature so that any movement of the armature is accompanied by a corresponding rotation of the vane. A coil of wire surrounds the permanent magnet in such a way that the magnetic field, due to current in it, is at right angles to the plane of the permanent magnet.

With this mechanical arrangement in mind let's see just how the unit functions. First, the magnetic field of the permanent magnet tends to keep the armature in a horizontal plane because the air gap allows the leakage flux to penetrate the soft iron of the armature. Under this condition, the armature assumed a position which enables the maximum amount of leakage flux of the permanent magnet to pass through it. In other words, the permanent magnet acts as the force which holds the armature at the zero current position.

The deflection of the armature and therefore the vane, is due to the magnetic field created when there is current through the shadow-graph coil. Its field is at right angles to that of the permanent magnet and therefore the combined field is distorted or changed in direction sufficiently to rotate the armature and attached vane. The greater the current in the coil, the greater its magnetic field and consequently the greater the angle through which the armature and vane are rotated.

From your former studies, you can see that the action of the shadow-graph is essentially that of a meter and therefore it can be used in place of the meter shown in Figure 4. The only difference being that instead of an ordinary pointer indicator, it has an optical system arranged so that the reading is represented by the width of the shadow formed on the screen.

The simple optical system is composed of a pilot lamp, placed behind the slit, so that the light is transmitted through the slit to a small screen. As the vane is located in the slit, the width of the shadow, cast on the screen, will be determined by the position of the vane, which is controlled by the current in the coil.

In most cases, the position of the vane is such that at maximum current, the shadow will have its greatest width. Therefore, when tuning in a station the shadow will narrow, due to the avc action, and become minimum at resonance.

SATURABLE CORE TUNING INDICATORS

The Saturable Core type of tuning indicator depends for its operation upon the variable impedance of an iron core inductance which carries a d-c magnetizing current. This may seem rather complicated but the principles involved have already been covered.

Filter chokes, as used in the ordinary power supply, carry both a-c and d-c current components and are usually rated in accordance with the values of direct current they will safely carry. This value of direct current must not be exceeded if the inductance of the filter choke is to be maintained.

In other words, the inductance of the choke coil depends in a marked degree upon the value of direct current in the coil, When the direct current in an iron core coil is excessive the core is said to be "saturated" and its inductance falls to a very low value.

Saying it in a little different way, when the core is saturated, it is impossible for the flux to change in accordance with the applied a-c voltages. This means there will be less reverse voltage set up and thus a lower value of inductance, or impedance.

In Figure 5, we have plotted a curve of direct current against inductance, or impedance, in an iron core coil. You can easily see that as the direct current increases, the impedance of the coil decreases. We do not show any actual values because, at the present time, we are interested only in the general shape of the curve.

To employ this principle to tuning indicators, it is generally found necessary to isolate the d-c winding, used to saturate the core, from the a-c winding which operates the tuning indicator. This is accomplished by using a transformer with two windings as shown in Figure 6.

Although this circuit is a simplified arrangement, it will show the action which takes place in a saturable core tuning indicator. The primary winding L_1, connected in series with the battery and variable resistor R, is used to carry the d-c and saturate the core. The secondary L_2, in series with the lamp, is connected across a low voltage a-c supply. In a receiver, this a-c supply is generally obtained from a winding on the power transformer.

Keeping the former explanations in mind, let's assume the variable resistor R is set so that the d-c current in L_1 is very low. From Figure 5, this shows that the impedance or inductance, of coil L_2, Figure 6, is high. Due to this high impedance, the current through the lamp will be low, and it will light dimly.

Now, let's imagine the resistance of R is adjusted to a low value and allows a high d-c current through L_1. As shown by the curve, this will cause a decrease in the impedance of L2, allow more current through the lamp and cause it to light more brilliantly.

The simple transformer arrangement of Figure 6 is not favorable for use in radio receivers because the a-c voltage in coil L_2, will induce a voltage in L_1, which is usually connected in the plate circuits of the avc controlled tubes. This condition of course, would cause an a-c hum in the speaker.

To overcome this difficulty, the windings are placed on a three-leg transformer core as shown in the lower part of Figure 7. The primary winding L_6, wound on the middle leg, has one end connected to the plates of tubes T_1 and T_2, through the primaries of their i-f transformers, and the other end to B+. Thus, coil L_6 will carry the plate current of both T_1 and T_2.

The secondary winding is in two sections, L_5 and L_7, wound on the outer legs of the core. These two sections are joined in such a way that the a-c current in each of them will induce equal and opposite voltages in the primary L_6, so that no net a-c voltage appears. The lamp is in series with the outer ends of the secondary sections which are connected in series across an a-c source.

Going over the rest of the circuit of Figure 7, we have two i-f amplifier tubes, T_1 and T_2, the control grids of which are connected to an avc voltage. With no input signal to the amplifier, the negative bias on the control grids will be minimum and the plate current maximum. As this current is in L_6, it will tend to saturate the core of the indicator transformer and lower the impedance of the secondary, causing the lamp to burn brightly.

When a signal is tuned in, the avc action will increase the negative bias on the control grids of T_1 and T_2, and cause a decrease of their plate currents. This, in turn, will increase the inductance of the secondary and dim the lamp. It can therefore be seen that with this system, resonance with an incoming signal will be indicated by a dimly lit lamp.

Another application of the saturable core principle, makes use of different colored lights to indicate resonance. As far as the mechanical arrangement is concerned, the dial scale lighting is accomplished by means of four red bulbs and three green bulbs spaced alternately behind the linear scale.

When no signal is tuned in, the red bulbs light brilliantly and the green bulbs are so dim that the net result is a red glow over the entire scale. When the signal is accurately tuned in, the red bulbs are dim and the green bulbs are sufficiently brilliant to cast a green glow over the scale. For intermediate positions, when the signal is only partly tuned in, the illumination is a combination of green and red which combines to produce a whitish light. The sequence of changes as a signal is tuned in, will be from red to white to green, the latter condition indicating resonance.

The electrical system employed to accomplish this action is shown in the circuits of Figure 8, where coils L_1 and L_2 are the primary and secondary of a saturable core transformer, like that explained for Figure 6. A separate tube T1, is employed to provide the D.C. saturating current and its control grid is connected to the A.V.C. voltage.

The lamp network consists of seven pilot lights connected to the secondary L2, while the A.C. voltage is obtained from a winding on the power transformer of the receiver. In our explanation, we will consider lamps T1, T2 and T3 as green, with T4, T5, T6 and T7 red.

Also, we will assume the impedance of L2 varies from 25 ohms to 700 ohms, the exact value at any instant, depending on the plate current of T1. That is, with no signal, the negative bias on T1 will be minimum and the plate current high, resulting in an impedance of 25 ohms for L2. With a strong signal, the negative bias on T1 will be maximum and the plate current low, causing the impedance of L2 to increase to 700 ohms.

Now, let us see what happens when we have a "no signal" condition in the receiver. As mentioned above, tube T1 will draw its maximum plate current and cause a 25 ohm impedance in L2. The resistance of the three green lamps will be quite high in comparison and the current in them so small that they will barely light. Under these conditions, however, the total current in L2 and the green lamps will be quite high and passing through the red lamps will cause them to be brilliantly illuminated.

When the receiver is tuned to a signal, we have an entirely different set of conditions. Due to the increased negative bias, the plate current of T1 will be low, and cause the impedance of L2 to increase to 700 ohms. In comparison to the resistance of the green lamps, this value is large enough to consider L2 as being open circuited.

With L2, thus eliminated, in effect we have nothing but a simple series circuit but the total current is less than in the former "no signal" condition because the shunting effect of L2 is removed. Not only is the total current reduced, but because of their parallel-series connection, the current in each red lamp will be only half of that in the green lamps.

The decrease in total current, and the division of current between the two parallel branch circuits of red bulbs, causes them to light dimly when a signal is received. The total current from the A.C. source however, must pass through the green lamps and therefore they light to full brilliancy.

Summarizing, the red lamps light brilliantly with no signal while the green lamps are brilliantly illuminated when the station is carefully tuned in and the entire action depends on the variable impedance characteristic of the secondary coil L2.

CATHODE RAY TUNING INDICATOR

Perhaps the most common type of tuning indicator in use today, is the "Magic Eye" tube. The action of this tube is very interesting but before going into detail, it is necessary that we explain the location of the various elements which make up the entire assembly.

For Figure 9, we show a simplified, cross sectional view of the tube, with all of the various elements properly marked and want you to pay particular attention to their location. You will notice that there are essentially two separate tubes with a common heater and a split cathode. One of these tubes is a triode which functions normally and, in case you have forgotten its operation, we suggest that you review the earlier Lessons.

The target of the other section is coated with a material which glows or fluoresces when electrons strike it. The purpose of the target is to attract electrons from cathode "k" and to show this action by fluorescing over a certain part of its coated area.

Between the cathode and target we show another element, technically known as the ray-control electrode, which is tied directly to the triode plate. As we will show later in our explanation, the operation of the visual indicator section of the tube depends on the control which the ray-control electrode can exercise over the area of the target which is struck by the electrons. In this section of the tube the purpose of the cathode is to supply the necessary electrons for the target.

The cathode light shield, which is made of an opaque substance, is placed directly over the cathode. Its purpose is to eliminate any of the light produced by the heater and usually black in color it gives one the impression of being the pupil of an "eye".

Tracing the circuit of this type of tube, as connected in Figure 10 the plus terminal of the 250 volt supply connects directly to the target and to the triode plate through resistor R2 while the cathode connects to the negative of the supply, as a return for the plate circuit. From the triode grid, there is a connection to the center arm of a potentiometer which is connected across a 12 volt battery, the plus of which is tied to the negative of the plate supply.

Forgetting the visual indicating section for a moment, we have the normal connections for the grid and plate voltages of a common heater type triode with the potentiometer, R_1, as a means of varying the grid voltage.

From our former explanations, you know that if the arm of the variable resistance is at the plus side of the battery, there will be zero bias, the plate current will be maximum and the voltage drop across R_2 will be the greatest. However, if the arm is at the extreme negative position, the grid bias will be maximum, there will be low plate current and the drop across R_2 will be small.

Go over the above explanation several times because, as the ray-control electrode is connected directly to the plate of the triode, it is actually the triode section which controls the electrons that strike the target.

Looking at Figure 10 again, and thinking of the tube as a whole, with the filament heated, the cathodes giving off electrons and the arm of the potentiometer set for zero bias, there will be maximum current in the plate circuit. Under these conditions the voltage drop across R_2 will be maximum.

With an assumed maximum drop of 200 volts across R_2 and a 250 volt supply, there will be 250-200 or 50 volts actually on the plate of the triode. As the ray-control electrode is directly connected to the plate, the 50 volts will also be applied to it. The voltage on the target is 250 volts, and thus, there is a difference of potential of 250 - 50 or 200 volts between the target and ray-control electrode. Hence, the ray-control electrode is 200 volts negative in respect to the target. Go over this last statement again because it is important.

Before going further, we want you to go back to Figure 9 and notice that the ray-control electrode is placed between the target and cathode. Thus, as it is 200 volts negative in respect to the target, the ray-control electrode is going to have a tendency to repel the electrons around it. This means that practically no electrons will reach a portion of the target affected by this action.

In Figure 11-A, we show a sketch of the top view of the "magic eye" with the cathode light shield removed to show the position of the elements. The shaded area is that part of the target which no electrons strike and, in actual operation, resembles a shadow. The other portion glows or fluoresces a greenish-yellow color. This large shadow is due to the repelling action of the ray-control electrode, which does not allow any electrons to strike that section of the target. A shadow of this type is found when the control grid bias voltage is practically zero.

Going back to Figure 10 again, but this time with the potentiometer arm in the negative position, resulting in a high bias voltage, the plate current will be small and we will assume the drop across R2 is only 5 volts.

Thus, we will have 245 volts on the ray-control electrode and the difference of potential between it and the target would only be 250 - 245 or 5 volts. Hence, the ray-control electrode will only be 5 volts negative in respect to the target and will not have any noticeable repelling action on the electrons.

Therefore, as shown in Figure 11-B, when there is a high negative voltage on the control grid of the triode section, the width of the shadow will be practically that of the physical dimensions of the ray-control electrode.

In order that you may become familiar with its application to radio receivers, in Figure 12 we have the simplified connections of a "Magic Eye" to a half wave rectifier tube T1 which functions as a second detector and A.V.C. rectifier.

Tracing the circuit, you will find the 250 volt supply connected directly to the target and through a dropping resistor, R2, to the plate of the triode section of the tuning indicator. The grid circuit is connected across the diode load resistor R and the drop across it, which depends on the signal strength, provides the negative grid bias.

With these connections, when we slowly tune in a station, the voltage at point X will gradually become more negative with respect to ground until, at resonance, (when the station is exactly tuned in) it will have maximum value. As this voltage is applied to the grid of the triode section, it will cause a variation of plate current which, in turn, will vary the voltage on the ray-control electrode.

Thus, when no station is tuned in, the ray-control electrode will be negative in respect to the target and the shadow on the screen will look like that of Figure 11-A. As resonance is gradually approached, the ray-control electrode becomes less negative, the shadow tends to narrow and, at resonance, will look like Figure 11-B. The size of the minimum shadow being determined by the mechanical dimensions of the electrode.

There are several types of cathode ray tuning indicators on the market but they all operate on the principles explained in this Lesson. Some are arranged to give a circular shadow instead of the angular type explained and there are various values of cut-off bias voltage of the triode section. For example, one type cuts off at -8 volts on the control grid while another has a -22 volt cut-off but, on both instances, there is +250 volts on the target. This variation of bias voltage is to compensate for the different control voltages developed across the avc rectifier.

Although the explanations of this Lesson have been on the so-called "accessories" of a radio receiver, their wide spread application makes a complete understanding of their operation necessary. Therefore, be sure that you understand all the principles before going to the next Lesson.

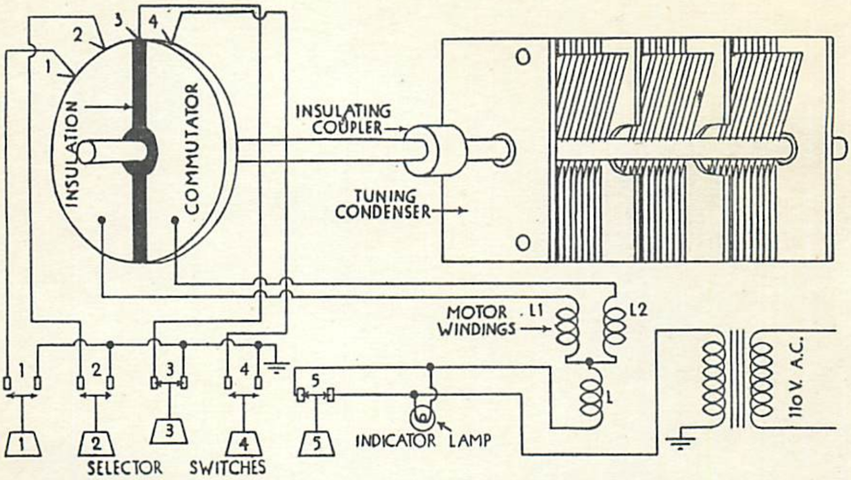


FIGURE 1

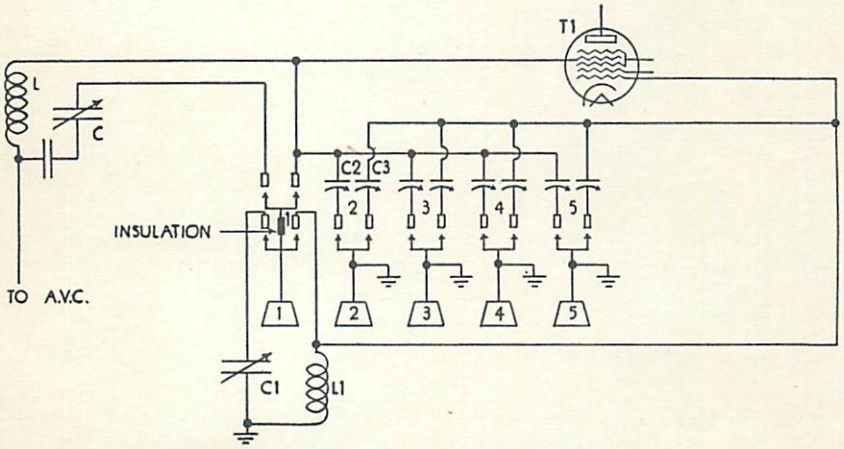


FIGURE 2

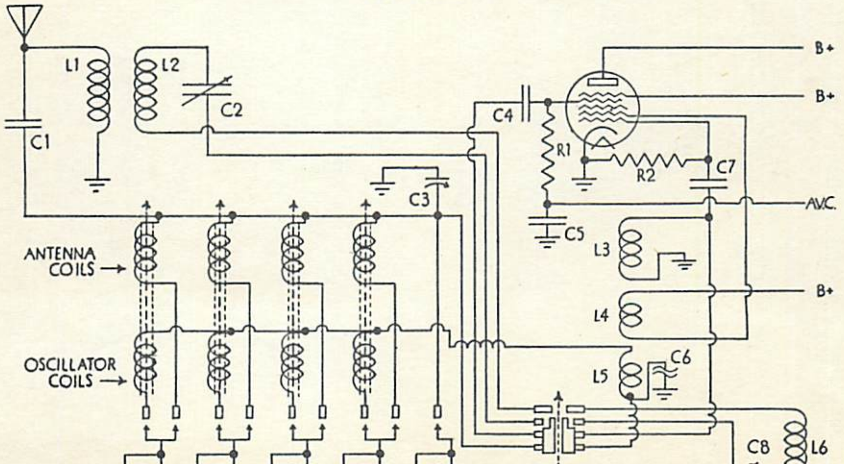


FIGURE 3

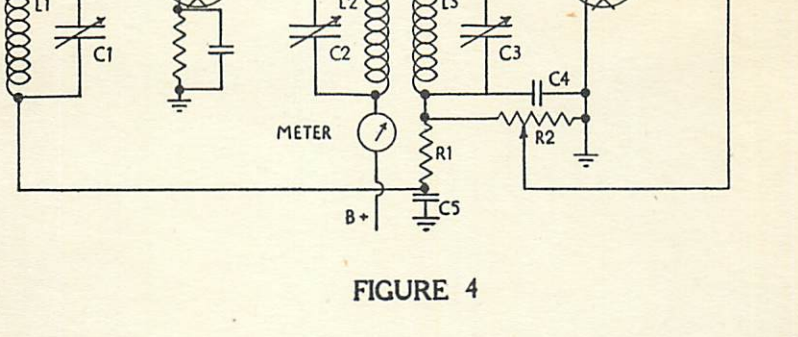
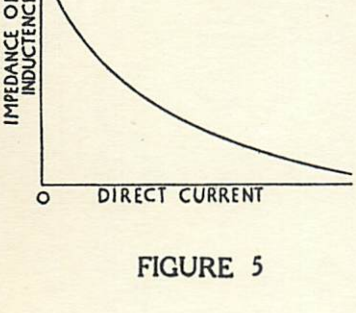


FIGURE 4



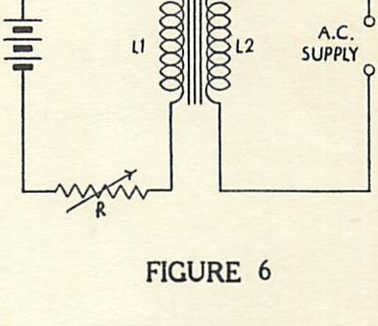


FIGURE 5

FIGURE 6

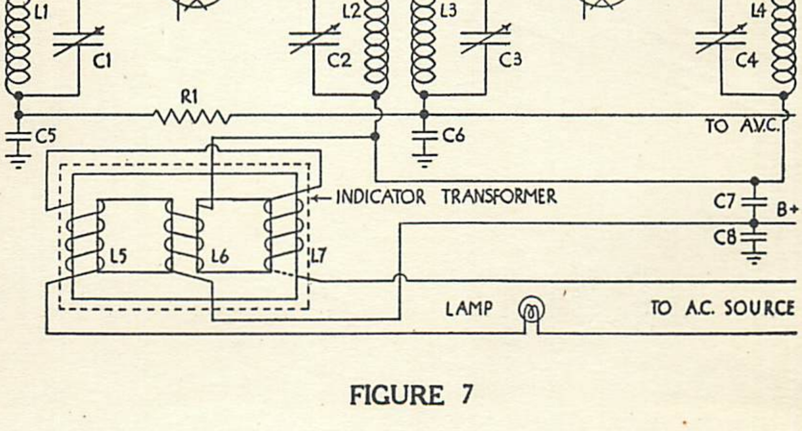


FIGURE 7

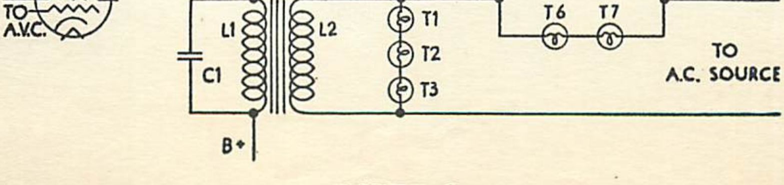


FIGURE 8

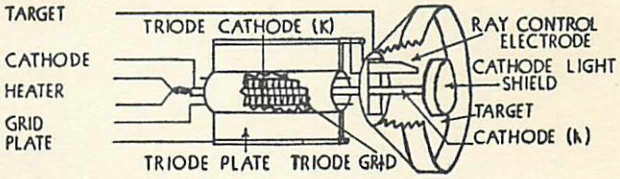


FIGURE 9

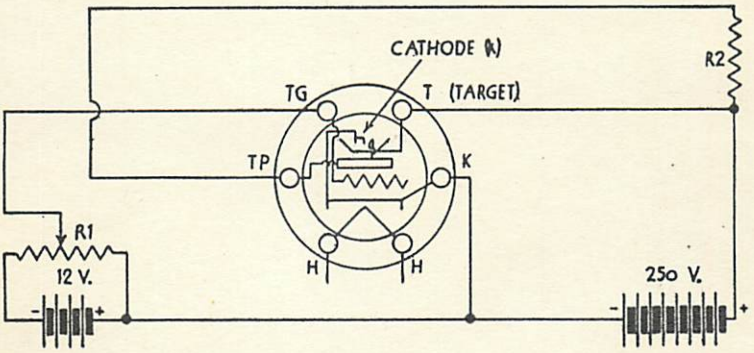
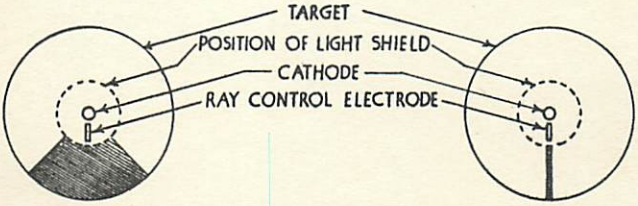


FIGURE 10



A

B

FIGURE 11

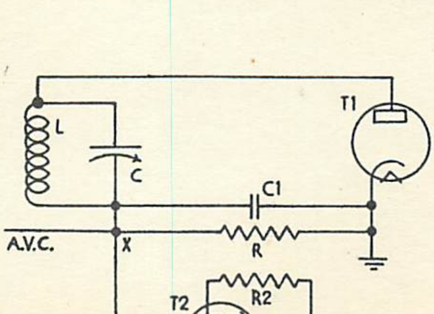


FIGURE 12

QUESTIONS AND ANSWERS

1. In general, what are the three main types of automatic station selector systems?
In general, the three main types of automatic station selector systems are (1) Mechanically Operated Manual Types, (2) Motor Operated Type and (3) Tuned Circuit Substitution Type.

2. What type of electronic motor is generally employed in "Motor Operated" station selector systems?
Split phase induction motors are generally employed in "Motor Operated" station selector systems.

3. In what receiver circuits is a "Tuned Circuit Substitution Type" station selector system connected?
A "Tuned Circuit Substitution Type" station selector system is connected in the grid circuits of the 1st detector and oscillator.

4. Electrically, how isthe inductance of the coils, in the automatic station selector of Figure 3, varied?
In Figure 3, the inductance of the automatic station selector coils is varied by changing the permeability of the core.

5. What are the three general classes of tuning indicators?
The three general classes of tuning indicators are (1) Meter, (2) Saturable core and (3) Cathode Ray.

6. What receiver circuit controls the action of most tuning indicators?
The avc circuit of a receiver controls the action of most tuning indicators.

7. When operating a receiver with a "Meter Type Indicator" should one tune for maximum or minimum meter current?
When a "Meter Type Tuning Indicator" is employed, one should tune the receiver for minimum current.

8. Does an increase of d-c current in the primary of a saturable core transformer increase or decrease secondary impedance?
An increase of d-c current in the primary of a saturable core transformer causes a decrease of secondary impedance.

9. With practically no bias voltage on the control grid of a "Cathode Ray Tuning Indicator" tube, will the shadow be large or narrow?
With practically no bias voltage on the control grid of a "Cathode Ray Tuning Indicator" tube, the shadow will be large.

10. Electrically, what is the purpose of all tuning indicators?
Electrically, the purpose of all tuning indicators is to assist the operator to tune the receiver to exact resonance with an incoming carrier.